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Materiel Test Procedure 2-2-615*
Aberdeen Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

SECURITY FROM DETECTION (VEHICLES)

1. OBJECTIVE

The purpose of this procedure is to provide a guide for test personnel to determine the extent to which a vehicle is secure from detection by the enemy.

2. BACKGROUND

Concealment has provided a large measure of the element of surprise on the battlefield. Muffled hoofs and tree branches, which once concealed cavalry, cannot hide a modern combat vehicle. However, care in design can help to minimize characteristics of sight and sound that can betray that vehicle.

The design of equipment for mechanized warfare has tended to work against concealment. Increased weapon size has produced more smoke, flash, and noise while greater weight and mobility requirements have led to more powerful engines meaning greater noise levels, hotter exhausts and the tendency toward exhaust "torching". These characteristics must be examined and the extent to which they interfere with the ability of a vehicle to escape detection must be evaluated.

3. REQUIRED EQUIPMENT

a. Suitable Test Sites and Facilities, for conducting detection tests, as required.

b. Equipment for conducting visibility tests, as required, including:

1) Motion Picture Cameras with Film.
2) Still Cameras with Film.
3) Test Courses for moving vehicle tests including level and hilly terrain.

c. Equipment for Conducting Audibility Tests, as required, including:

1) Microphones (to conform to ASA Z24.8 - 1949).
2) Magnetic tape recorders.
3) Octave Band Noise Analyzer (to conform to ASA Z24.10 - 1953).
4) Test Course (circular or figure eight) for conducting jury tests.
5) Microphone Calibration Equipment.

d. Equipment as required for conducting infrared detection tests as described by the applicable sections of MTP 2-2-812.

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e. Meteorological Equipment, as required, including:

1) Thermometers
2) Barometer
3) Anemometer
4) Wind vane
5) Humidity and Air Density Measurement Equipment

f. "Standard" Vehicle(s).
g. Polar Coordinate Graph Paper.
h. Field Communications Equipment, as required,.
i. Maintenance Support Facilities, as required.

4. REFERENCES

A. Woomert, Dale E., A Research Test to Evaluate the Techniques and Precision of the Measurements of Smoke from Diesel Engines, Aberdeen Proving Ground, Report DPS-1204, March 1964.
B. American Standard Test Code for Apparatus Noise Measurement, American Standards Association, 1950.
C. Peterson and Gross, Handbook of Noise Measurement, West Concord, Massachusetts, General Radio Company, 5th Edition, 1963.
D. MTP 2-2-812, Infrared Emission from Vehicles.
E. MTP 3-3-811, Noise and Blast Measurements.
F. MTP 4-2-700, Propelling Charges.

5. SCOPE

5.1 SUMMARY

This MTP describes the procedures to be followed for the evaluation of the characteristics of a vehicle which render it susceptible to detection, and of the extent to which measures taken to minimize these characteristics are effective.

The procedures described concern the detection by sight, sound, and infrared techniques of uncamouflaged, unaltered combat vehicles under a variety of normal conditions which they are likely to be subjected.

Included in the procedures are the following:

a. Vehicle visibility tests:

1) Detection through size, shape, and silhouette characteristics
2) Detection by visible hot surfaces

b. Exhaust visibility tests:

1) Detection by smoke visibility.
2) Detection by exhaust flames.
3) Detection through visibility of the ice fog phenomenon in arctic environment.

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c. Road dust pattern visibility tests.
d. Illumination visibility:

1) Detection by the exterior lights associated with vehicle operation in darkness.
2) Detection through the leakage of interior illumination around armament openings, hatches, etc.

e. Infrared detection as described in the applicable sections of MTP 2-2-812.
f. Audibility tests:

1) Noise distribution of stationary and moving vehicles.
2) Jury tests to evaluate the noise characteristics of the vehicle.

g. Ground signature tests:

(A determination of any features of the trail which a vehicle makes which tend to identify it).

In addition, discussions of visibility and audibility test considerations are included as APPENDIX A and APPENDIX B, respectively.

5.2 LIMITATIONS

The scope of this procedure shall be limited to assessing the vulnerability of an uncamouflaged vehicle to detection from ground-level positions.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Pre-Scheduling Conditions

a. Experienced driver crews, observer personnel and test personnel shall be available and fully briefed to ensure that:

1) Testing time is minimized
2) Test data is authoritative
3) Training time for "new" equipment is lessened

b. Ensure that the required equipment and facilities are available at the test sites when required.

6.1.2 Vehicle Preparation

Prior to testing:

a. Ensure that the test vehicle and a "standard vehicle" (if applicable)

are in a "ready-service" condition (fuel, oil water, etc.).

b. The highest grade of fuel shall be used in all subtests in which the vehicles are required to be operated, unless otherwise specified.

NOTE: A "standard" vehicle shall be required whenever comparison tests are to be made or comparison test data is not available.

c. Ensure that the vehicle illuminating systems are operable.

d. Record the following for the test vehicle and the "standard" vehicle (as applicable):

1) Nomenclature
2) Model number
3) Serial number
4) Manufacturer
5) Fuel nomenclature (as required)

e. Determine and record the following data at the testing site prior to each test conducted:

1) Time of day
2) Ambient lighting condition
3) Weather condition

6.1.3 Equipment Preparation

Prepare the equipment, as required, for the individual tests, such as:

a. Photographic equipment
b. Anemometer
c. Thermometers
d. Microphones
e. Magnetic tape recorders
f. Test site communication equipment

6.2 TEST CONDUCT

Visibility and audibility tests may be conducted simultaneously whenever possible to minimize total test time.

6.2.1 Visibility Tests

a. During the conduct of each visibility test, collect and record the following meteorological data at the testing site:

1) Ambient
2) Relative humidity
3) Wind velocity

b. The following shall be observed during the conduct of visibility tests:

1) Visibility conditions shall be clear, even in darkness.
2) A minimum of 3 observers shall be used for each test.
3) Photography shall be used whenever possible to document the results.
4) No data shall be taken under a specific engine operating (steady-state) condition until torque, speed and temperatures have been maintained, substantially constant, for at least one minute.
5) Observations shall be made without the use of optical aids.
6) Observations shall be made over terrain free from visual obstructions.

6.2.1.1 Vehicle Visibility

Record the following for each observation:

a. Vehicle identity
b. Observer orientation with respect to the vehicle
c. Observer identity
d. Observation number

6.2.1.1.1 Size, Shape and Silhouette - Perform the following on the test item and a "standard" item, in stationary positions, on a clear sunlit day:

a. Determine and record the maximum distance at which the vehicle is discernible against a background of:

1) Trees
2) Brush
3) Tall grass

b. View each vehicle under the conditions of step a in the following orientation with respect to the observers:

1) Front view
2) Side views
3) Angular views, front (approximately 45°)
4) Angular views, rear (approximately 45°)
5) Rear view

NOTE: Use qualified observers positioned so that the vehicles are not backlighted (i.e., the sun shall be at the observers' backs).

c. Record the background description for each observation.
d. Record comments on the reflective surfaces which are discernible in the various viewing orientations.

e. Record comments on the test item silhouette symmetry which tend to reveal its position and identity.

f. Photograph the test vehicle and the "standard" vehicle at the various angles and distances using the considerations discussed in APPENDIX A.

g. Repeat steps a through f for the test vehicle and the "standard" vehicle on a clear moonlit night.

NOTE: Avoid orientations where the vehicles are backlighted.

6.2.1.1.2 Hot Surfaces - Perform the following under conditions of darkness (blackout) with the test vehicle and the"standard"vehicle combat loaded and in a stationary position.

a. Determine and record the maximum distances and radial directions at which hot surfaces engine components, exhaust components, etc.) of the vehicles can be detected under the following conditions:

1) Vehicle engines operating at low idle
2) Vehicle engines operating at maximum rpm
3) Vehicle engines operating at mid-range rpm

NOTE: Vehicle "warm-up" times shall be of sufficient length to ensure that "steady-state" conditions are obtained for each observation.

b. Determine and record the minimum distances and the radial directions that hot surfaces are visible to observers at a height of 15 feet, under the operating conditions of step a.

c. Repeat steps a and b until a minimum of 3 observations have been made for each operating condition.

d. Record the following for each observation:

1) Engine operating speed
2) Nomenclature of visible surfaces
3) Vehicle identity
4) Observer identity
5) Observation number

6.2.1.2 Exhaust Visibility

NOTE: Exhaust visibility is a characteristic primarily associated with diesel-powered vehicles, therefore, these tests need not be performed on vehicles with spark-ignition engines.

The following instructions shall be applicable to exhaust visibility tests:

a. Vehicles shall be operated by at least 3 different drivers during each of the tests.

b. Vehicle engines shall be serviced for normal operation under the

prevailing climatic conditions.

c. Control rack adjustments shall be made, as specified, for the particular engine.

d. Fuel grades used during the test shall be those specified for engine operation under the particular climatic condition.

e. Observations shall be made with the observers in the most advantageous positions to veiw the exhaust outlet opening.

6.2.1.2.1 Smoke - Perform the following in clear sunlight, under moderate ambient temperatures with low relative humidity, and with the test vehicle and the "standard" vehicle fully combat loaded.

a. Determine and record the exhaust smoke classifications as listed in APPENDIX A under the following operating conditions in a stationary position:

1) Engine operating at low-idle
2) Engine operating at maximum rpm
3) Engine operating at mid-range rpm
4) Engine accelerating to maximum rpm
5) Engine decelerating to low idle

NOTE: Observations shall not be conducted when the wind velocity is greater than 10 mph.

b. Repeat step a until a minimum of 3 observations have been made for each condition.

c. Record the following for each observation:

1) Engine operating speed (steady-state)
2) Engine speed range (transient)
3) Fuel grade nomenclature
4) Temperature and humidity condition
5) Vehicle identity
6) Observation number
7) Observer identity
8) Driver identity

d. Operate the vehicles, at 5 mph, over a test course consisting of the following types of terrain:

1) Level paved road
2) Level cross-country
3) Hilly paved roads with slope grades between 10 and 60 percent, as applicable
4) Hilly cross-country

NOTE: The vehicles shall be driven at full control rack position (corresponding to full throttle).

e. Determine and record the exhaust smoke visibility classifications (as listed in APPENDIX A) during the traverse of each course section.

f. Repeat steps d and e until at least three observations have been made for each course section.

g. Re d the following for each observation:

1) Course section description
2) Engine operating speed
3) Control rack position
4) Fuel grade nomenclature
5) Vehicle identity
6) Observer identity
7) Driver identity
8) Observation number

h. Repeat steps d through g with the vehicles operating at increasing speeds, in increments of 5 mph, until the maximum rated speed for the individual course sections is obtained.

i Obtain color photographs of the various exhaust smoke conditions.

j. Repeat steps d through i with the vehicles operated at partial control rack position (approximately 1/2 throttle).

k. Repeat steps a through j, using the appropriate fuel grades, under the following conditions:

1) Moderate ambient temperatures and high relative humidity
2) High ambient temperatures and low relative humidity
3) High ambient temperatures and high relative humidity
4) Low ambient temperatures and low relative humidity
5) Low ambient temperatures and high relative humidity

6.2.1.2.2 Flames - Perform the following in darkness (blackout), under moderate ambient temperatures with low relative humidity, and with the test vehicle and the "standard" vehicle fully combat loaded:

a. Determine and record the maximum distances at which exhaust flames are visible under the following operating conditions in a stationary position:

1) Engine operating at low idle
2) Engine operating at maximum rpm
3) Engine operating at mid-range rpm
4) Engine accelerating to maximum rpm
5) Engine decelerating to low idle

b. Repeat step a with a minimum of three observations for each condition.

c. Record the following for each observation:

1) Engine operating speed (steady-state)
2) Engine operating speed range (transient)
3) Fuel grade nomenclature
4) Vehicle identity
5) Observer identity

6) Driver identity
7) Observation number

d. Operate the vehicles, at 5 mph, over the test course described in paragraph 6.2.1.2.1, step d.

NOTE: The vehicles shall be driven at full control rack position (corresponding to full throttle).

e. Determine and record the maximum distances that the exhaust flames are visible during the traverse of each course section.

NOTE: Observations shall be made with the observers oriented to view the exhaust system outlet opening.

f. Repeat steps d and e until at least 3 observations have been made for each course section.

g. Record the following for each observation:

1) Course section description
2) Engine operating speed
3) Control rack position
4) Fuel grade nomenclature
5) Vehicle identity
6) Observer identity
7) Driver identity
8) Observation number

h. Repeat steps d through g with the vehicles operating at increasing speeds in increments of 5 mph until the maximum rated speed for the individual course sections is attained.

i. Obtain still and motion picture photographs of the various exhaust flame conditions using the considerations of Appendix A.

j. Repeat steps d through i with the vehicles operated at partial control rack position (approximately 1/2 throttle)

k. Repeat steps a through j using the appropriate fuel grades, under the following conditions:

1) Moderate ambient temperatures and high relative humidity
2) High ambient temperatures and low relative humidity
3) High ambient temperatures and high relative humidity
4) Low ambient temperatures and low relative humidity
5) Low ambient temperatures and high relative humidity

6.2.1.2.3 Ice Fog - Perform the following on a clear day with ambient temperatures below -25 °F for the test vehicle and the standard vehicle:

a. Determine whether the vehicle exhaust system produces an ice fog phenomenon under the following conditions in a stationary position:

1) Vehicle engine operating at low idle

2) Vehicle engine operating at maximum rpm
3) Vehicle engine operating at mid-range rpm

NOTE: Observations shall not be conducted when the wind velocity is greater than 10 mph.

b. Determine and record the ultimate height of the ice fog cloud, as applicable, by:

1) Estimation from visual observations.
2) Photographing the ice fog phenomenon and the vehicles from a suitable vantage point.

c. Determine and record the maximum distance that the ice fog phenomenon is visible (against an appropriate background).

d. Repeat steps a through c until a minimum of 3 separate observations have been made for each condition.

e. Record the following for each observation:

1) Engine operating speed.
2) Comments on the relative sizes of the ice fog clouds of characteristic of both vehicles.
3) Vehicle identity.
4) Observer identity.
5) Driver identity.
6) Observation number.

6.2.1.3 Road Dust Pattern Visibility

Perform the following on a clear sunlit day with the test vehicle and the "standard" vehicle fully combat loaded:

a. Operate the vehicles, separately, over a selected section of dusty cross-country terrain at 5 mph.

NOTE: 1. If there is appreciable wind in or away from the direction of travel, the vehicles shall be driven in both directions.
2. The dust pattern tests shall not be conducted if the wind velocity exceeds 8 mph.

b. Record the resultant dust cloud from each vehicle on color motion picture film.

NOTE: Utilize appropriate vantage points in order to determine the ultimate height of the dust cloud.

c. Repeat the steps a and b until a minimum of 3 observations have been made for each vehicle.

d. Record the following for each observation:

1) Engine operating speed.
2) Comments on the placement of engine exhaust pipes, cooling air exhausts and vehicle peculiarities as contributing factors to the dust pattern.
3) Vehicle identity.
4) Observer identity.
5) Driver identity.
6) Observation number.

e. Repeat steps a through d with the vehicles operating at increasing speeds in increments of 5 mph until the maximum rated speed for the slower vehicle is attained.

6.2.1.4 Illumination Visibility

6.2.1.4.1 Exterior Illumination - Perform the following in darkness (blackout) for the test vehicle and the "standard" vehicle in stationary positions:

a. Determine and record the maximum distances and the radial directions that the following (as applicable) are visible to the observers at eye level:

1) Service headlights
2) Service taillight(s)
3) Service stoplights(s)
4) Blackout marker stoplight
5) Blackout driving light(s)

b. Determine and record the minimum distances and the radial directions that the lights in step a (as applicable) are visible to observers at a height of 15 feet.

c. Repeat steps a and b until a minimum of 3 observations have been made for each light and condition.

d. Record the following for each observation:

1) Light identity
2) Light location on the vehicle
3) Vehicle identity
4) Observer identity
5) Observation number

6.2.1.4.2 Interior Illumination - Perform the following in darkness (blackout) for the test vehicle and the "standard" vehicle in stationary positions with the vehicles in the "buttoned" down configuration and the combat lighting and instrument lighting illuminated:

NOTE: 1. Determinations are to be made on the basis of white interior lighting if the vehicle does not have combat (orange-red) lighting.
2. "Buttoned" down configurations pertain to closed vehicles only.

a. Determine and record the maximum distances and the radial directions that the vehicle interior lighting and various instrument lights (as applicable) are visible to the observers at eye level.

NOTE: 1. Particular attention shall be given to light visibility around mantlet openings.
2. Ensure that optical instruments are unobscured from inside the vehicles.

b. Determine and record the minimum distances and the radial directions that the interior illumination and instrument lights are visible to observers at a height of 15 feet.

NOTE: Direct observations from a 15 foot height can be simulated by backing the vehicle up a slope to an appropriate angle of 17 degrees.

c. Repeat steps a and b until a minimum of 3 observations have been made for each condition.

d. Record the following for each observation:

1) Location(s) of light detected
2) Light identity
3) Vehicle identity
4) Observer identity
5) Observation number
6) Type of interior lighting

6.2.2 Susceptibility to Infrared Detection

Determine the susceptibility of the test item to detection by infrared devices as described by the applicable sections of MTP 2-2-812.

6.2.3 Audibility Tests

During the conduct of audibility tests, collect and record the following meteorological data at the testing site:

a. Ambient temperature
b. Barometeric pressure
c. Relative humidity
d. Air density
e. Wind velocity
f. Wind direction
g. Cloud cover description

NOTE: 1. Audibility tests shall not be conducted when the wind velocity at the testing site is greater than 10 mph.
2. Other audibility test considerations are discussed in Appendix B.
3. Tests shall be conducted at dawn in order to minimize

extraneous noises and to provide a "standard" of detection susceptibility using the "worst" condition.

6.2.3.1 Noise Distribution Tests

NOTE: 1. Microphones used in noise distribution tests shall conform to ASA Z24.8 - 1949.
2. Each microphone shall provide the input to a high quality tape recorder.

6.2.3.1.1 Stationary Vehicle Tests - Perform the following in moderate ambient temperatures and low relative humidity for the test vehicle and the "standard" vehicle:

a. Emplace the microphones at successive positions, 45 degrees apart, around the test item and the "standard" item in a circular pattern at a radial distance of 25 feet.

b. Determine and record the noise level and the noise distribution around each vehicle under the following operating conditions:

1) Vehicle engines operating at low idle
2) Vehicle engines operating at maximum rpm
3) Vehicle engines operating at mid-range rpm

c. Record audio bandwidths in the range of 10 to 10,000 cycles per second.

d. Repeat steps a through c until a minimum of 3 observations have been conducted.

e. Repeat steps a through d with the microphones positioned at a radial distance of 50 feet.

f. Record the following for each observation:

1) Radial distance of microphones from the vehicles
2) Engine operating speed
3) Microphone identification
4) Tape recorder identification
5) Vehicle identity
6) Observer identity
7) Driver identity
8) Observation number

g. Repeat steps a through f under the following conditions:

1) Moderate ambient temperatures and high relative humidity
2) High ambient temperatures and low relative humidity
3) High ambient temperatures and high relative humidity
4) Low ambient temperatures and low relative humidity
5) Low ambient temperatures and high relative humidity

6.2.3.1.2 Moving Vehicle Tests - Perform the following under moderate ambient temperatures and low relative humidity for the test vehicle and the "standard"

vehicle:

a. Emplace two microphones, at a suitable driving site, 25 feet apart.

b. Drive the vehicles, in 8 major compass directions, over a position 25 and 50 feet from the microphones.

c. Record audio bandwidths, for each pass over the prescribed position, in the range of 10 to 10,000 cycles per second.

d. Repeat steps a through c until a minimum of 3 observations have been conducted for each driving direction.

e. Repeat steps a through d with the vehicles driven at speeds up to the maximum for the slower vehicle in increments of 5 mph.

f. Record the following for each determination:

1) Vehicle operating speed
2) Engine operating speed
3) Microphone identification
4) Tape recorder identification
5) Vehicle identity
6) Observer identity
7) Driver identity
8) Observation number

g. Repeat steps a through f under the following conditions:

1) Moderate ambient temperatures and high relative humidity
2) High ambient temperatures and low relative humidity
3) High ambient temperatures and high relative humidity
4) Low ambient temperatures and low relative humidity
5) Low ambient temperatures and high relative humidity

6.2.3.2 Jury-Type Noise Tests

Perform the following in moderate ambient temperatures with low relative humidity for the test vehicle and the "standard" vehicle:

a. Operate the vehicles, simultaneously, but at opposite ends, over a test course of circular or figure-eight configuration consisting of:

1) Hard surfaced road
2) Cross-country terrain

NOTE: A low gear rate shall be used so that engine noise will be at or near maximum levels. Other considerations are discussed in Appendix B.

b. With a "jury" of observers positioned at a distance of 200 yards from the center of the test course, rate the vehicles with respect to each other by the noise which each produces.

NOTE: 1. A "jury" shall consist of a minimum of 3 observers.

2. Jury members shall possess good hearing ability with a normal human frequency response distribution.

c. Repeat steps a and b until a minimum of three runs have been made by the vehicles over the test course.

d. Repeat steps a through c at increased observation distances, in increments of 200 yards, until the threshold of hearing is approached.

e. Record the following for each test run:

1) Observation distance.
2) Test vehicle noise relative to "standard" vehicle noise.
3) Directional effects due to orientation of the vehicle with respect to the observer.
4) Observer identity.
5) Run number.
6) Course layout description.

f. Repeat steps a through e for the following conditions:

1) Moderate ambient temperatures and high relative humidity.
2) High ambient temperatures and low relative humidity.
3) High ambient temperatures and high relative humidity.
4) Low ambient temperatures and low relative humidity.
5) Low ambient temperatures and high relative humidity.
6) Low ambient temperatures with surroundings under heavy snow cover.

6.2.4 Ground Signature Tests

Perform the following with the test vehicle and the "standard" vehicle fully combat loaded, as applicable:

a. Operate the vehicles over the following level test courses at slow to moderate speeds:

1) Paved road - asphalt
2) Cross-country terrain - heavy dust
3) Cross-country terrain - mud
4) Paved or cross-country terrain - heavy new snow

b. Determine and record the characteristics of the vehicle imprint (track or trail), which is distinctive of the vehicle itself, over each type of terrain and condition of step a.

c. Repeat steps a and b until a minimum of 3 observations have been made by each observer.

d. Record the following for each observation:

1) Type and condition of terrain traversed
2) Vehicle identity
3) Observer identity
4) Observation number

6.3 TEST DATA

6.3.1 Preparation for Test

a. Record the following for the test vehicle and the "standard" vehicle:

1) Nomenclature
2) Model number
3) Serial number
4) Manufacturer
5) Fuel nomenclature (as required)

b. Record the following prior to each test conducted:

1) Time of day in hours
2) Ambient lighting condition (daylight, darkness, dawn, etc.)
3) Weather condition (moderate temperature and low humidity, etc.)

6.3.2 Test Conduct

6.3.2.1 Visibility Tests

Record the following for each visibility test conducted:

a. Ambient temperature in degrees F.
b. Relative humidity in percent
c. Wind velocity in mph
d. Wind direction (NE, S, NW, etc.)

6.3.2.1.1 Vehicle Visibility -

Record the following for each observation:

a. For all vehicle visibility tests:

1) Vehicle identity (test vehicle, "standard" vehicle).
2) Observer identity.
3) Observer orientation with respect to the vehicle (front view, left side view, 45° angle to right front, etc.).
4) Observation number (1, 2, 3).

b. For size, shape and silhouette observations:

1) Maximum distance at which vehicle is discernible in yards.
2) Background description (trees, brush, tall grass).
3) Reflective surfaces discernible (description and comments).
4) Comments on silhouette symmetry which tend to reveal vehicle position and identity.

c. For hot surface observations:

1) Maximum distance at which a hot surface is visible in yards.
2) Observers radial direction with respect to the vehicle in degrees.
3) Nomenclature of visible surfaces.
4) Engine operating speed in rpm.
5) Minimum radial distance at which a hot surface is visible from a height of 15 feet.
6) Observer's radial direction with respect to the vehicle in degrees.

6.3.2.1.2 Exhaust Visibility -

Record the following for each observation:

a. For all exhaust visibility tests:

1) Vehicle identity (test vehicle, "standard" vehicle)
2) Observer identity
3) Driver identity
4) Observation number (1, 2, 3)

b. For exhaust smoke visibility tests of stationary vehicles:

1) Exhaust smoke classification (Grade 1, 2, 3, 4, or 5).
2) Engine operating speed in rpm (for steady-state conditions only).
3) Engine operating speed range in rpm (for transient conditions only).
4) Fuel grade nomenclature.

c. For exhaust smoke visibility tests of moving vehicles:

1) Exhaust smoke classification (Grade 1, 2, 3, 4, or 5).
2) Vehicle operating speed in mph.
3) Engine operating speed in rpm.
4) Control rack position (full, partial).
5) Course section description (level paved road, hilly paved road with 15% grade, etc.).
6) Fuel grade nomenclature.

d. For exhaust flame visibility tests of stationary vehicles:

1) Maximum distance at which exhaust flames are visible in yards.
2) Engine operating speed in rpm (for steady-state conditions only).
3) Engine operating speed range in rpm (for transient conditions only).
4) Fuel grade nomenclature.

e. For exhaust flame visibility tests of moving vehicles:

1) Maximum distance at which exhaust flames are visible in yards.
2) Vehicle operating speed in mph.
3) Engine operating speed in rpm.
4) Control rack position (full, partial).
5) Course section description (level paved road, hilly paved road with 15% grade, etc.).
6) Fuel grade nomenclature.

f. For ice fog visibility tests:

1) Engine operating speed.
2) Ultimate height of ice fog cloud in feet.
3) Maximum distance that ice fog cloud is visible in yards.
4) Background against which ice fog was observed (clear sky, trees, etc.).

6.3.2.1.3 Road Dust Pattern Visibility -

Record the following for each observation:

a. Vehicle identity (test vehicle, "standard" vehicle)
b. Observer identity
c. Driver identity
d. Observation number (1, 2, 3)
e. Vehicle operating speed in mph
f. Engine operating speed in rpm
g. Comments on the placement of:

1) Engine exhaust pipes.
2) Cooling air exhausts.
3) Vehicle peculiarities contributing to dust pattern characteristics.

6.3.2.1.4 Illumination Visibility -

Record the following for each observation:

a. For exterior illumination visibility tests:

1) Vehicle identity (test vehicle, "standard" vehicle).
2) Maximum distance at which the exterior light is visible in yards.
3) Observer's radial direction with respect to the vehicle in degrees.
4) Light identity (service headlight, blackout driving light, etc.).
5) Light location (front, rear, left front, etc.).
6) Minimum radial distance at which the exterior light is visible at a height of 15 feet, in feet.
7) Observer's radial direction with respect to the vehicle in

degrees.
8) Observer identity.
9) Observation number (1, 2, 3).

b. For interior illumination visibility tests:

1) Vehicle identity (test vehicle, "standard" vehicle).
2) Maximum distances at which interior light is visible in yards.
3) Location(s) of interior light detected.
4) Light identity (dome light leak, instrument light, etc.).
5) Type of lighting in use (white lighting, combat lighting).
6) Observer's radial direction with respect to the vehicle in degrees.
7) Minimum radial distance at which interior lighting is visible at a height of 15 feet, in feet.
8) Observer's radial direction with respect to the vehicle in degrees.
9) Observer identity.
10) Observation number (1, 2, 3).

6.3.2.2 Susceptibility to Infrared Detection

Data shall be collected and recorded as described in the applicable sections of MTP 2-2-812.

6.3.2.3 Audibility Tests

Record the following at each testing site for each audibility test:

a. Ambient temperature in degrees F.
b. Barometric pressure in inches of Hg
c. Relative humidity in percent
d. Air density in pounds per cubic foot
e. Wind velocity in mph
f. Wind direction (NE, S, NW, etc.)
g. Cloud cover description (dense, partial, scattered, etc.)

6.3.2.3.1 Noise Distribution Tests -

Record the following for each observation:

a. For all noise distribution tests:

1) Vehicle identity (test vehicle, "standard" vehicle).
2) Observer identity.
3) Driver identity.
4) Observation number (1, 2, 3).
5) Microphone identification.
6) Tape recorder identification.
7) Vehicle noise audio bandwidths in range of 10 to 10,000 cycles per second (cps).

b. For noise distribution tests of stationary vehicles:

1) Radial distance of microphones from the test vehicle in feet
2) Engine operating speed in rpm

c. For noise distribution tests of moving vehicles:

1) Vehicle operating speed in mph.
2) Engine operating speed in rpm.
3) Microphone distances from the preselected position in feet.
4) Vehicle direction (north to south, northwest to southwest, etc.).

6.3.2.3.2 Jury-Type Noise Tests -

Record the following for each observation:

a. Vehicle identity (test vehicle, "standard" vehicle).
b. Observation distance from the center of the vehicle in feet.
c. Observer identity.
d. Driver identities.
e. Observation number (1, 2, 3).
f. Course layout (circular, figure-eight).
g. Test vehicle noise relative to test vehicle noise.
h. Directional effects due to the orientation of the test vehicle with respect to the observer.
i. Presence of snow cover, as applicable.

6.3.2.4 Ground Signature Tests

Record the following for the test vehicle and the "standard" vehicle:

a. Distinctive features of the vehicle imprint (track or trail) on a particular type of terrain condition.
b. Type and condition of terrain traversed.
c. Vehicle identity (test vehicle, "standard" vehicle).
d. Observer identity.
e. Observation number (1, 2, 3).

6.4 DATA REDUCTION AND PRESENTATION

Data taken from observations of the test vehicle and the "standard" vehicle, for each observer, shall be averaged and tabulated for comparison. Qualitative observer comments shall also be noted in the final evaluation. Photographs and movies shall be retained, suitably identified, analyzed, and compared for each vehicle.

Observation distances and radial directions shall be plotted on polar coordinate graph paper and suitably identified and keyed to the narrative evaluations.

An analysis of the susceptibility of the test vehicle to detection because of its size, shape, or silhouette shall be made taking into consideration the background and the lighting conditions.

Evaluation of the effectiveness of the hot surface shielding shall be made and compared to that of the "standard" vehicle. Recommendations for the improvement of shielding shall be made as required based on the conclusions drawn from the observation data.

The evaluation of the exhaust system visibility shall include correlation of the results with such factors as engine speed, weather conditions, vehicle speed, type of terrain traversed, type of fuel used, and driver characteristics. Conclusions drawn from the comparison and analysis of photographs of the vehicles must be included as part of the narrative report. The locations of the various exhaust system components must be evaluated in terms of their contribution to the vehicle's overall detectibility.

Particular angles at which the vehicle lights and light leakages are visible shall be noted and tabulated or plotted.

Analysis of the noise distribution data collected for stationary and moving vehicles shall be accomplished as described in Appendix B. The microphone outputs are fed into an analyzer to obtain a spectrum analysis of the sound pressure levels as a function of frequency as described in MTP 4-2-804. Bandwidths recorded are 10 to 10,000 cps, but analysis is usually based on the range of 10 to 4800 cps. Sound pressure levels can be plotted against frequency as described in Appendix B and shown in Figure B-1. Note that the evaluation concerns the effectiveness of sound-energy absorbing material on the vehicle. Correlations of vehicle noise to engine speed, vehicle speed, gear ratio, and meteorological conditions shall also be made. For tests of moving vehicles, the data shall be normalized to 50 feet. Other considerations, such as continuous frequency analysis, through re-recording on "clean" tape loops, shall be utilized when time becomes especially important.

Jury test results of vehicle noise studies shall be presented in tabular form keyed to plots on polar coordinate graph paper showing the course layout and observer positions. Comments by individual observers shall be compared.

Infrared detection tests results shall be presented as described by MTP 2-2-812.

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APPENDIX A

VISIBILITY TEST CONSIDERATIONS

1. INTRODUCTION

Prior to conducting vehicle visibility tests, no special vehicle preparation is necessary. However, the vehicle should be reasonably clean, its engine functioning properly and be in a "ready service" condition (i.e., gas, oil).

The main interest in conducting visibility tests on an engineering basis, is to determine the extent that a vehicle through its being operated provides the means of being visually detected. Areas of chief interest are:

a. Vehicle visibility:

   1) Size, shape and silhouette
   2) Hot surfaces

b. Exhaust visibility:

   1) Smoke
   2) Flames
   3) Ice fog

c. Road dust visibility
d. Illumination visibility:

   1) Exterior illumination
   2) Interior illumination

It must be understood that special detecting devices to aid in seeing a vehicle are not used in these tests since it is the intent to which the vehicle gives itself away to observers, as compared to those which it, presumably, will replace, that is important. Consequently, detection of vehicles by radar and aerial surveillance does not fall within the scope of this MTP.

2. VEHICLE VISIBILITY

2.1 SIZE, SHAPE AND SILHOUETTE

Ordinary visibility of a vehicle should be tested against various backgrounds. A comparison of views from various angles and distances of two similar vehicles is desirable. In the case of smaller vehicles, comparisons are made when the vehicles are partially obscured by brush or tall grass. The vehicles are viewed under normal conditions and care should be taken to view them without enhancing the susceptibility of the vehicle to visual detection.

The mere outline or silhouette of a vehicle can be compared with that of another by comparing elevation drawings. This, however, is not a measure of

the relative visibility of the two against a heterogenous background. It must also be noted that a relatively symmetrical shape will be more conspicuous than one of equal area having an irregular outline.

Reflecting surfaces should be observed and reported with respect to vehicle orientation and lighting conditions. Obvious attempts to minimize the number of reflective surfaces must be taken into consideration.

Photography can be employed to evaluate vehicle visibility. By photographing test and "standard" vehicles from the same distance and camera angle, and under the same lighting conditions then size and shape comparisons can be made to show these effects on vehicle visibility.

It must be pointed out that differences in paint pigments may cause photographs to exaggerate the visibility of a vehicle particularly those taken in black and white. It is well to advise the photographer that a picture giving an accurate monochrome rendition of the subject is desirable. Color prints may also be desirable if conditions warrant their use.

2.2 HOT SURFACES

Red hot exhaust systems constitute a source of visible radiation that can also betray a vehicle at night unless the surfaces are shielded. Night observations must be made to determine the extent to which these surfaces are visible. Since illumination is of such low level, photography is difficult, hence, visual observations must be reliable.

Observations are made with the test vehicle and the "standard" vehicle fully combat loaded and at varying engine speeds to determine the angles and elevations (with respect to the vehicle) at which the hot surfaces are visible under conditions of normal usage.

3. EXHAUST VISIBILITY

3.1 SMOKE

Exhaust smoke is a problem associated principally with diesel engines. The amount and characteristic color and intensity of the smoke produced is determined by vehicle operating conditions such as load, fuel, temperature, humidity, and rack position.

Observations of exhaust smoking should be made throughout the daylight portions of the testing period to provide data for representative operating conditions.

Exhaust smoking can occur for a variety of reasons such as driver variations, fuel grade differences, engine load, weather conditions and terrain. Qualitative determinations can be made by setting up smoke classifications by color and correlating the observed smoke conditions with the other variables. Smoke classification by color is listed as follows:

Smoke Description	Classification
Clear	1
Haze	2
Light gray	3
Medium gray	4
Dark gray to black	5

Photography can also be a useful tool for evaluating smoke conditions, however, the same precautions as those pertaining to the photographing of exhaust fumes (paragraph 2.2) must be observed.

3.2 FLAMES

Exhaust flames, particularly torching, occur when a high concentration of unburned fuel in the exhaust gases is ignited by hot exhaust manifolds and pipes. This phenomenon is best observed after dark under varying load and speed conditions, particularly during acceleration and deceleration.

To best determine whether exhaust flames are detectable and the extent to which they affect the security of a vehicle, photography is utilized. The effect is photographed using either still or motion picture cameras. The exhaust flames furnish the illumination and the vehicle is not lighted externally. Comparison photographs of different vehicles must be made under identical conditions.

3.3 ICE FOG

Ice fog, a phenomenon associated with operation under conditions of extreme cold, is often visible at great distances, particularly in convoy operations. Ice fog should be observed qualitatively during the conduct of tests under arctic conditions. Visibility characteristics attributable to the design of the exhaust system should be particularly recorded. Thus, a vehicle which disperses engine exhaust with cooling air may be less visible than one exhausting upward without turbulence.

4. ROAD DUST VISIBILITY

Road dust disturbances caused by poorly located exhaust pipes, engine cooling air exhausts or other vehicle peculiarities must also be taken into consideration. The visibility of the dust pattern raised by the test vehicle is evaluated by comparing it with dust from a comparable "standard" vehicle operating under the same conditions.

To compare the dust patterns, each vehicle is operated separately over a selected section of a dusty cross-country course at various speeds and the dust pattern observed. Qualitative observations are to be made from appropriate vantage points and the heights of the dust clouds recorded on color motion picture film for later analyses.

5. ILLUMINATION VISIBILITY

5.1 EXTERIOR ILLUMINATION

The locations of exterior lights on the test item must be compared to their locations on the "standard" vehicle. Vehicles are viewed from various distances, elevations, and at various radial positions in darkness. Care must be taken to ensure that the observer's eyes are fully adapted to darkness.

The maximum distances at which each light is visible at various angles and elevations shall be determined and plotted on polar coordinate graph paper and the particular light identified and located with respect to vehicle features.

5.2 INTERIOR ILLUMINATION

The extent to which the interior lights of a combat vehicle can betray its position is observed at various distances in darkness. Three observers are used to view the vehicle from all directions. Care must be taken to ensure that the observer's eyes are fully adapted to darkness. When light is detected, the distance of observation is increased, and the positions at which the light is no longer observed are recorded. When the elevation of the vehicle is too high for direct observation of the light, the vehicle may be backed up a slope to get the desired angle (about 17 degrees). Care shall be taken to see that periscopes and sights are unobscured from the inside. Particular attention should be given to light leakage around the mantlet openings provided for primary and secondary armament, and around hatches.

Results may be shown graphically using polar coordinate paper. It is necessary to describe fully the circumstances of light leakage and recommendations for rectifying the leakage shall be made, whenever possible.

APPENDIX B

AUDIBILITY TEST CONSIDERATIONS

1. INTRODUCTION

The betrayal of vehicles through mechanical noise is a familiar and natural result of complex equipment with large power plants. To the basic engine and driving mechanisms of early military vehicles there have been added more complex cooling systems, automatic hydraulic transmissions, superchargers, auxiliary power plants, and component mechanisms such as the hydraulic pumps and motors used for control systems. The cumulative noise creates a complicated spectrum which is diffucult to analyze objectively, not only because of the complexity of the human ear, but because of the many variables which affect the transmission of sound under outdoor conditions. An example of the noise level of a tracked vehicle at 17 mph is shown in Figure B-1.

2. NOISE MEASUREMENT BY INSTRUMENTS

To diagnose noise, the general procedure is to place dynamic microphones in a sound field. The microphone outputs are recorded on magnetic tape. When played back, the tape output can be fed to an analyzer to obtain a spectrum analysis of the sound pressure levels as a function of the frequency as described in MTP 3-2-811.

Decisions concerning the arrival direction of the sound at the microphone(s) and other considerations influencing microphone location are made in accordance with the criteria of the American Standard Test Code for Apparatus Noise Measurement, (refe nce 4B).

Surveys of noise distribution around stationary or moving vehicles must take into account equipment configuration, environment, and other pertinent factors so that microphone locations can be decided upon and utilized to provide results which can be properly interpreted.

Because frequency analyses of recorded noise is time consuming, the desired section(s) of magnetic tape may be re-recorded on a loop of "clean" tape, so that the same noise may be continuously inserted into the analyzer.

3. JURY TESTS BY OBSERVERS

The sense of hearing remains a suitable method for evaluating the relative loudness of vehicle noise when the vehicles are operating at considerable distances from an observer. This is because sensing devices often have difficulty discriminating between ambient noise and that emanating from the vehicle(s) of interest, and, also, because of the difficulty of capturing noise as it affects the human ear. Furthermore, it is a sense of hearing that is directly involved when one speaks of detecting a vehicle by means of the noise it makes.

To utilize the human ear as a qualitative noise measuring device, jury-type tests are conducted for comparing a "standard" venicle with the test vehicle.

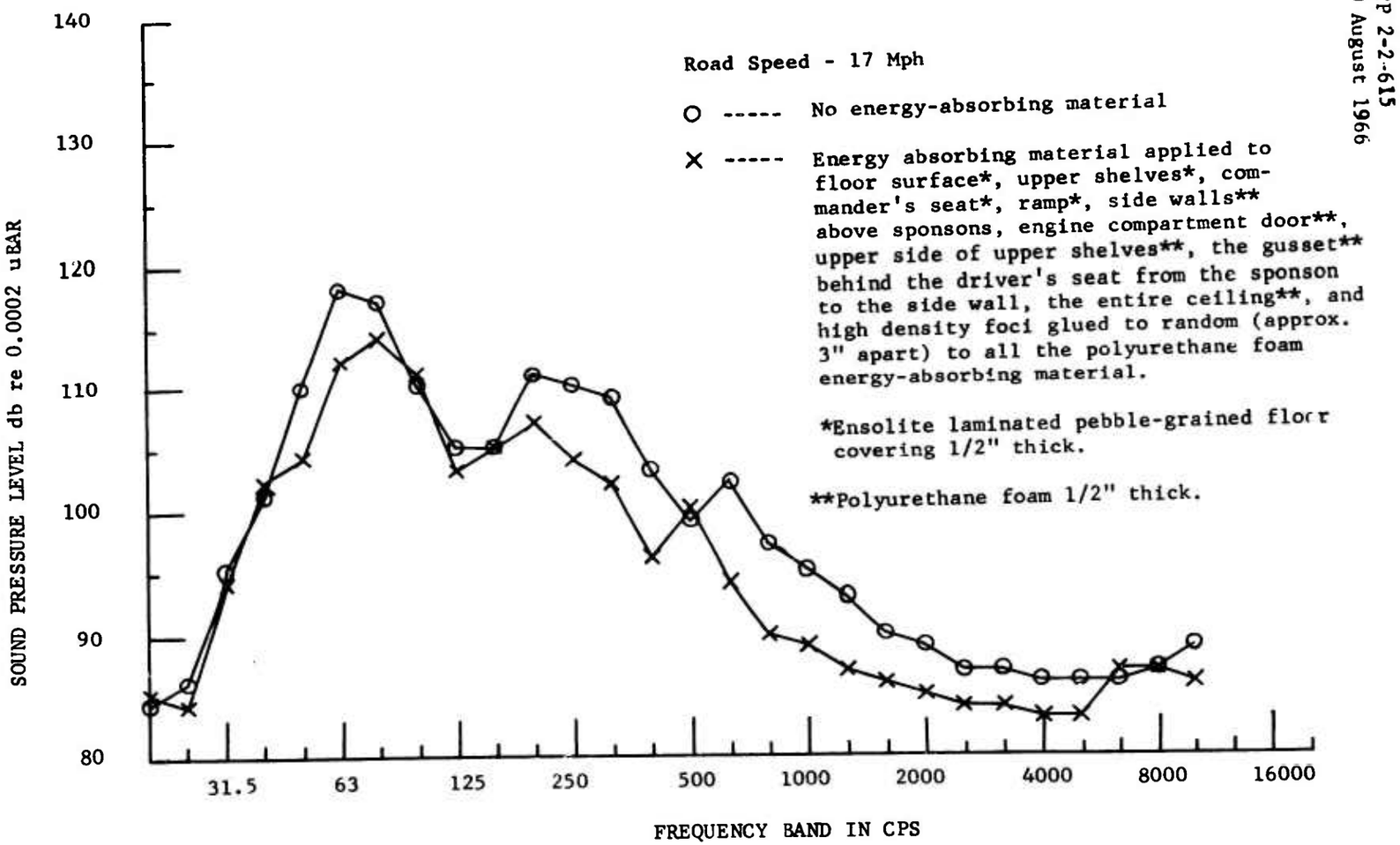

Figure 8-1. Noise Level of Carrier, Command Post, Light Tracked, M577, USA Reg. No. 12Z163 at Ear Level of Personnel Seated at Right Rear Position

These tests consist of independent observations made by a specified number of highly trained "jury" members. Each observer must have good hearing ability with normal human frequency response distribution. The assumption is made in tests of this nature that comparisons based upon individual vehicles will be acceptable if several vehicles are operating in convoy.

Tests are, generally, conducted on both hard-surface roads and over cross-country terrain with vehicles operating in circles and/or figure-eights. This provides opportunities for observing directional effects, particularly in the case of the engine, which can be considerably masked from some directions.

It is preferable to conduct these tests at a distance from which both vehicles can be heard regardless of instantaneous orientation with respect to the observers. A low gear ratio should be used so that engine noise will be at or near maximum-for-the-course condition. When suspension system or track noises are the principal concern, however, it may be desirable to operate in the gear producing the lowest level of engine and transmission noise.

The tests should be conducted with the observers positioned at various distances to allow for differences in vehicle types and for differences in the surrounding conditions such as wind direction, ambient noise, humidity, air density, presence of snow cover, etc. However, when the observation distance is increased to the threshold of hearing, the effects of ambient noise and outside interferences increase so that greater care in judgment must be exercised in the observations.